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ASSISTANT PROFESSOR SIGNAL OFFICE.

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THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. VII. ANN ARBOR, MAY, 1890. NO. 1.

ORIGINAL ARTICLES.

CONCERNING THERMOMETERS.

BY PROFESSOR WM. A. ROGERS.

The question incidentally raised by Professor Marvin in his communication to the January number of the JOURNAL relating to the proper method of determining the true height of the mercurial column of a thermometer for points between the graduations, seems to the writer to need further investigation. Three methods of procedure are available:

(a) Eye-estimates of the fractional subdivisions of the graduated scale. These may be made either directly, without the aid of a magnifying glass, with the help of an eye lens or through a telescope placed at a distance from the thermometers compared. There will, I apprehend, be no difference of opinion in regard to the preference to be given to the latter method in observations of precision.

(b) Filar micrometer measures of the height of the column with respect to the nearest preceding graduation of the stem. I have found it advisable to make a complete observation consisting of three settings, viz., (1) for coincidence with the preceding graduation, (2) for coincidence with the meniscus of the mercurial column, (3) for coincidence with the graduation immediately following. In a set of continuous comparisons, the

micrometer interval corresponding to the distance between the graduations may be determined in a separate series, but it will not be safe to depend upon tabular values previously determined.

(c) Eye-piece micrometer measures of the height of the column with respect to the preceding graduation. The writer has not found this method practicable on account of the difficulty of making the limiting lines of the eye-piece scale correspond exactly with the adjacent subdivisions on the stem. There is also the further objection that this correspondence can only be maintained for unequal subdivisions of the scale at the expense of departure from a constant magnifying power.

If simultaneous observations, by the three methods indicated, give substantially identical results, it will be clear that either may be chosen indiscriminately. Speaking only from my own experience, the first two methods give results which differ systematically with a persistence which forbids the supposition that the discordances may be due to accidental errors of observation.

We have here a problem which is closely allied to the problem of "personal equation" in astronomical observations. It will probably be found that the relative equation between eye-estimates and micrometer measures will vary with the experience of the observer, but that when a fixed habit of observation has been acquired the equation will become nearly constant.

It is clear, also, that this equation may change, either with a change of personality in making eye-estimates or by any cause which affects the micrometer readings or from both causes combined. A telescope of low magnifying power and long focal distance appears, in my own case, to give results somewhat at variance with those obtained with a telescope of moderately short focal distance and high magnifying power.

In making the observations it has been my custom to make the eye-estimate in advance of the micrometer reading, taking care to remove the micrometer line a little distance from the meniscus in order to avoid the effect of near association. Substantially identical results were found for all the thermometers investigated. The corrections for a fifth degree thermometer were found to be about one-fifth of those for a thermometer

having degree graduations, the two scales having nearly the same distances between the graduations. The comparisons were made with a theodolite placed about three feet in front of the thermometers compared. One division of the micrometer was found to be 0.0019°. In the following table the numbers given represent the fractional part of the entire distance between the graduations. In a thermometer having degree graduations they represent hundredths of a degree. In a thermometer graduated to tenths of a degree they represent thousandths of a degree. These values are to be applied to determinations by eye-estimates in order to reduce them to equivalent filar micrometer measures.

Reading of Scale.	Corr.	Reading of Scale.	Corr.	Reading of Scale.	Corr.	Reading. of Scale.	Corr.
0.00°	+.01	0.30°	+.08	0.55°	—.02	0.80°	—.10
0.05	+.05	0.35	+.06	0.60	—.04	0.85	—.09
0.10	+.06	0.40	+.04	0.65	—.08	0.90	—.07
0.15	+.07	0.45	+.02	0.70	—.09	0.95	—.03
0.20	+.08	0.50	+.01	0.75	—.11	0.98	+.00
0.25	+.09						

In a paper presented at the Toronto meeting of the American Association for the Advancement of Science, the writer called attention to the systematic character of the pulsatory movements of a mercurial column under a uniformly rising or falling temperature. At the same time Mr. R. S. Woodward, of the U. S. Geological Survey, presented a theoretical investigation of the physical conditions under which these movements must exist if they result from the action of certain forces connected with the thermometers themselves. The writer also called attention to the other alternative, viz., that they might possibly be due to the personal equation of the observer in estimating the subdivisions of the scale. It will be interesting therefore, to apply corrections subsequently determined, to the observations which formed the basis of that paper. *But it is to be noted that whatever may be the cause of the systematic differences here pointed out, if they exist in any series of comparisons any single comparisons is subject to an error which can be, to a certain extent, eliminated either by the application of a tabular correction, or still more nearly by taking the mean of readings made at equal inter-*

vals during the entire time required for a complete cycle of changes to take place.

It has been found that this method of comparison by cycles gives results which are surprisingly accordant with the mean of a very large number of comparisons made at random, while the probable error of a single comparison is reduced from about 0.05° to a little less than 0.02° in the case of a thermometer graduated to half degrees.

From the large number of observations available, two series are selected as typical cases. In the first series, the thermometers compared rested horizontally in an iron box about four feet in length. They were protected by a thick glass plate, which effectually excluded the outside air. The readings were made with an eye-lens of low magnifying power.

In the second series the readings were made with the aid of a telescope, having a focal length of about eight feet. This series was undertaken with the hope that the observations might furnish evidence in support of the view that these systematic deviations may in some way result from a difference in the thermal capacity of the glass stem and that of the mercurial column, causing slow changes through the stem, which, uniting with the more rapid changes through the bulb might possibly produce harmonic movements. All the thermometers compared have degree graduations except number 1503, which was kindly loaned to me by the Chief of the Signal Service. This thermometer, which has received exact comparisons with an air thermometer, forms the basis of all meteorological investigations undertaken by the writer since 1888.

SERIES I.

Comparison of Signal Service Standard Thermometer No. 1503 (½°) with Thermometer Green No. 2834 (1°).

Time. h. m.	1503	2834	1503 minus 2834	Time. h. m.	1503	2834	1503 minus 2834
1 34	56.°50	56.°45	+.°05	1 57	57.°85	57.°91	—.°06
35	56.52	56.50	+.02	1 58	57.90	57.95	—.05
36	56.60	56.62	—.02	1 59	57.93	57.95	—.02
37	56.65	56.69	—.04	2 00	57.97	57.99	—.02
38	56.71	56.79	—.08	2 01	58.00	58.03	—.03
39	56.77	56.90	—.13	02	58.02	58.02	+.00

Time.	1503	2834	1503 minus 2834	Time.	1503	2834	1503 minus 2834
h. m.	°	°	°	h. m.	°	°	°
40	56.90	56.96	−.06	03	58.04	58.02	+.02
41	56.96	56.95	+.01	04	58.07	58.03	+.04
42	56.98	56.98	+.00	05	58.13	58.03	+.10
43	57.02	57.00	+.02	06	58.20	58.05	+.15
44	57.02	57.00	+.02	07	58.28	58.10	+.18
45	57.06	57.02	+.04	08	58.38	58.13	+.25
46	57.24	57.04	+.20	09	58.46	58.15	+.31
47	57.24	57.04	+.20	10	58.50	58.28	+.22
48	57.27	57.06	+.21	11	58.52	58.40	+.12
49	57.45	57.14	+.31	12	58.55	58.55	.00
50	57.46	57.20	+.26	13	58.57	58.62	−.05
51	57.50	57.20	+.30	14	58.59	58.70	−.11
52	57.52	57.28	+.24	15	58.65	58.80	−.15
53	57.53	57.45	+.08				
54	57.53	57.60	−.07				
55	57.63	57.76	−.13				
56	57.71	57.80	−.09				

Series II.

Comparison of Thermometers Green Nos. 4730 and 4731 with Green No. 1094.

Vertical suspension in air. Nos. 4730 and 4731 were first immersed in water at 88° for ten minutes. The bulbs alone were then packed with fine ice for ten minutes. After this both thermometers were suspended near No. 1093 which had meanwhile taken the temperature of the surrounding air. The points at which sudden changes occur are marked with an asterisk. The comparisons extend from 9 h. 13 m. to 12 h. 34 m., the interval between the successive observations being one minute. The removal from melting ice occurred at 9 h. 11 m. 30 s. No. 4730 has a very thick shell and small stem. No. 4731 has a very thin shell and thick stem.

4730	4731	1094	1094 minus 4730	1094 minus 4731	4731 minus 4730
°	°	°	°	°	°
36.95	34.80	38.15	+1.20	+3.35	−2.15
37.08	35.00	38.20	+1.12	+3.20	−2.08
37.30	35.40	38.20	+.90	+2.80	−1.90
37.75	35.92	38.20	+.45	+2.25	−1.80
37.92	36.18	38.28	+.36	+2.10	−1.74
37.98	36.70	38.40	+.42	+1.70	−1.28
38.02	36.98	*38.52	+.50	+1.54	−1.04
38.08	37.03	38.70	+.62	+1.67	−1.05
38.15	37.20	38.78	+.63	+1.58	−.95
38.25	37.55	38.85	+.60	+1.30	−.70
38.52	37.80	38.92	+.40	+1.12	−.72
38.70	37.90	38.96	+.26	+1.06	−.80
38.78	38.00	39.00	+.22	+1.00	−.78
38.89	38.05	39.00	+.11	+.92	−.84
38.94	38.18	39.02	+.08	+.84	−.76
38.97	38.23	39.04	+.07	+.81	−.74
39.01	38.55	39.05	+.04	+.50	−.46
39.03	38.70	39.12	+.09	+.42	−.33
39.06	38.80	39.18	+.12	+.38	−.26
39.18	38.90	39.28	+.10	+.38	−.28
39.40	38.95	39.38	−.02	+.43	−.45
39.60	39.00	*39.65	+.05	+.65	−.60

4730	4731	1094	1094 minus 4730	1094 minus 4731	4731 minus 4730
°	°	°	°	°	°
39.78	39.00	39.70	—.08	+.70	—.78
39.93	39.12	39.80	—.13	+.68	—.81
40.02	39.20	39.85	—.17	+.65	—.82
40.03	39.28	39.83	—.20	+.55	—.75
40.06	39.45	39.90	—.16	+.45	—.61
40.09	39.55	40.00	—.09	+.45	—.54
40.12	39.70	40.02	—.10	+.32	—.42
40.20	39.78	40.02	—.18	+.24	—.42
40.30	39.85	40.02	—.28	+.17	—.45
40.35	39.85	40.08	—.27	+.23	—.50
40.40	39.95	40.12	—.28	+.17	—.45
*40.68	39.95	40.15	—.53	+.20	—.73
40.74	39.97	40.30	—.44	+.33	—.77
40.80	40.00	*40.50	—.30	+.50	—.80
40.85	40.00	40.60	—.25	+.60	—.85
40.90	40.05	40.68	—.22	+.63	—.85
40.97	40.10	40.76	—.21	+.66	—.87
41.00	40.12	40.85	—.15	+.73	—.88
41.02	40.18	40.87	—.15	+.69	—.84
41.03	40.28	40.94	—.09	+.66	—.75
41.06	*40.52	41.00	—.06	+.48	—.54
41.11	40.68	41.00	—.11	+.32	—.43
41.15	40.80	41.03	—.12	+.23	—.35
41.25	40.85	41.04	—.21	+.19	—.40
*41.50	40.90	41.06	—.44	+.16	—.60
41.60	40.90	41.12	—.48	+.22	—.70
41.70	40.95	41.18	—.52	+.23	—.75
41.85	41.00	*41.35	—.50	+.35	—.85
41.95	41.00	41.50	—.45	+.50	—.95
41.98	41.00	41.70	—.28	+.70	—.98
41.99	41.10	41.75	—.24	+.65	—.89
42.01	41.20	41.82	—.19	+.62	—.81
42.00	*41.30	41.90	—.10	+.60	—.70
42.08	41.55	42.00	—.08	+.45	—.53
41.10	41.75	42.02	—.08	+.27	—.35
42.12	41.84	42.02	—.10	+.18	—.28
*42.40	41.90	42.04	—.36	+.14	—.50
42.60	41.95	42.10	—.50	+.15	—.65
		10 hours and 13 minutes.			
42.69	41.96	42 10	—.59	+.14	—.73
42.78	41.98	42.10	—.68	+.12	—.80
42.85	42.00	42.18	—.67	+.18	—.85
42.88	42.02	42.32	—.56	+.30	—.86
42.90	42.10	*42.50	—.40	+.40	—.80
42.95	42.12	42.70	—.25	+.58	—.83
42.98	42.19	42.78	—.20	+.59	—.79
43.00	43.25	42.85	—.15	+.60	—.75
43.03	*43.32	42.90	—.13	+.58	—.71
43.08	42.60	42.96	—.12	+.36	—.48
43.10	42.76	43.00	—.10	+.24	—.34
43.14	42.83	43.00	—.14	+.17	—.31
43.25	42.88	43.02	—.23	+.14	—.37
43.35	42.90	43.04	—.31	+.14	—.45
*43.65	42.95	43.09	—.53	+.17	—.70

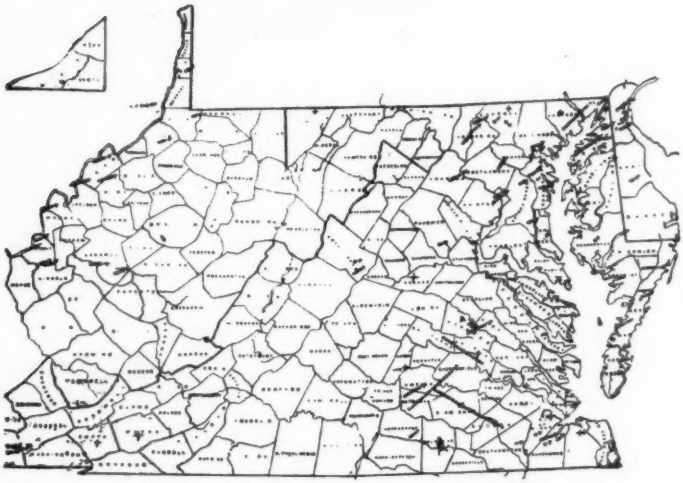
4730	4731	1094	1094 minus 4730	1094 minus 4731	4731 minus 4730
°	°	°	°	°	°
		(10 hours and 13 minutes).			
43.70	42.98	43.16	—.54	+.18	—.72
43.86	43.00	43.20	—.66	+.20	—.86
43.90	43.00	43.25	—.65	+.25	—.90
43.92	43.06	*43.48	—.44	+.42	—.86
43.95	43.10	43.68	—.27	+.58	—.85
43.98	43.15	43.78	—.20	+.63	—.83
43.99	43.20	43.83	—.16	+.63	—.79
43.91	43.30	43.84	—.07	+.54	—.61
44.02	*43.50	43.90	—.12	+.40	—.52
44.02	43.68	43.90	—.12	+.22	—.34
44.06	43.78	43.97	—.09	+.19	—.28
44.10	43.85	44.00	—.10	+.15	—.25
44.12	43.88	44.02	—.10	+.14	—.24
44.18	43.90	44.02	—.16	+.12	—.28
*44.30	43.95	44.04	—.26	+.09	—.35
44.45	43.98	44.06	—.39	+.08	—.47
44.60	44.00	44.08	—.52	+.08	—.60
44.66	44.12	44.13	—.53	+.01	—.54
44.78	44.15	44.18	—.60	+.03	—.63
44.82	44.30	44.26	—.56	—.04	—.52
44.88	*44.60	*44.45	—.43	—.15	—.28
44.97	44.78	44.55	—.42	—.23	—.19
44.98	44.80	44.70	—.28	—.10	—.18
44.99	44.88	44.75	—.24	—.13	—.11
45.00	44.90	44.85	—.15	—.05	—.10
45.00	44.95	44.85	—.15	—.10	—.05
45.03	44.97	44.90	—.13	—.07	—.06
45.06	45.00	44.96	—.10	—.04	—.06
45.12	45.02	45.00	—.12	—.02	—.10
*45.22	45.06	45.02	—.20	—.04	—.16
45.45	45.13	45.04	—.41	—.09	—.32
45.66	45.18	45.06	—.60	—.12	—.48
45.70	*45.26	45.11	—.59	—.15	—.44
45.80	45.40	45.15	—.65	—.25	—.40
45.85	45.60	45.20	—.65	—.40	—.25
45.90	45.75	*45.35	—.55	—.40	—.15
45.96	45.82	45.50	—.46	—.32	—.14
45.98	45.88	45.68	—.30	—.20	—.10
46.00	45.95	45.78	—.22	—.17	—.05
46.02	45.95	45.88	—.14	—.07	—.07
46.05	45.98	45.94	—.11	—.04	—.07
46.10	46.00	45.96	—.14	—.04	—.10
46.15	46.03	46.02	—.13	—.01	—.12
46.18	46.04	46.02	—.16	—.02	—.14
*46.30	46.15	46.04	—.26	—.11	—.15
		11 hours and 13 minutes.			
46.55	46.18	46.06	—.49	—.12	—.37
46.65	46.20	46.10	—.55	—.10	—.45
46.76	*46.30	46.15	—.61	—.15	—.46
46.80	46.62	46.18	—.62	—.44	—.18
46.90	46.70	46.28	—.62	—.42	—.20
46.95	46.78	*46.36	—.59	—.42	—.17
46.98	46.82	46.50	—.48	—.32	—.16

4730	4731	1094	1094 minus 4730	1094 minus 4731	4731 minus 4730
°	°	°	°	°	°
		(11 hours and 13 minutes.)			
46.98	46.88	46.65	—.33	—.23	—.10
47.00	46.90	46.73	—.27	—.17	—.10
47.00	46.93	46.78	—.22	—.15	—.07
47.00	46.95	46.82	—.18	—.13	—.05
47.02	46.96	46.85	—.17	—.11	—.06
47.00	46.98	46.88	—.12	—.10	—.02
47.00	46.98	46.90	—.10	—.08	—.02
47.02	47.00	46.93	—.09	—.07	—.02
47.02	47.01	46.96	—.06	—.05	—.01
47.05	47.02	46.98	—.07	—.04	—.03
47.06	47.03	47.00	—.06	—.03	—.03
47.10	47.04	47.02	—.08	—.02	—.06
47.18	47.08	47.03	—.15	—.05	—.10
47.28	47.15	47.03	—.25	—.12	—.13
*47.48	47.22	47.06	—.42	—.16	—.26
47.52	47.25	47.10	—.52	—.25	—.27
47.70	*47.35	47.13	—.57	—.22	—.35
47.76	47.50	47.16	—.60	—.34	—.26
47.80	47.70	47.22	—.58	—.48	—.10
47.90	47.78	*47.28	—.62	—.50	—.12
47.95	47.80	47.40	—.55	—.40	—.15
47.96	47.83	47.58	—.38	—.25	—.13
47.98	47.90	47.68	—.30	—.22	—.08
48.00	47.95	47.78	—.22	—.17	—.05
48.00	47.96	47.83	—.17	—.13	—.04
48.01	47.97	47.87	—.14	—.10	—.04
48.00	47.98	47.90	—.12	—.10	—.02
48.04	48.00	47.96	—.08	—.04	—.04
48.06	48.02	47.96	—.10	—.06	—.04
48.14	48.04	48.02	—.12	—.02	—.10
*48.25	48.06	48.04	—.21	—.02	—.19
48.40	48.18	48.06	—.34	—.12	—.22
48.58	48.20	48.10	—.48	—.10	—.38
48.70	48.25	48.14	—.56	—.11	—.45
48.78	*48.45	48.18	—.60	—.27	—.33
48.85	48.55	48.26	—.59	—.29	—.30
48.90	48.70	48.29	—.61	—.41	—.20
48.92	48.75	48.40	—.52	—.35	—.17
48.95	48.80	*48.50	—.45	—.30	—.15
48.95	48.82	48.56	—.39	—.22	—.13
48.97	48.96	48.70	—.27	—.16	—.01
48.98	48.90	48.76	—.22	—.14	—.08
48.99	48.92	48.79	—.20	—.13	—.07
49.00	48.94	48.83	—.17	—.11	—.06
49.00	48.97	48.86	—.14	—.11	—.03
49.02	48.98	48.92	—.10	—.06	—.04
49.04	49.00	48.95	—.09	—.05	—.04
49.12	49.00	49.00	—.12	—.00	—.12
49.16	49.04	49.02	—.14	—.02	—.12
*49.26	49.06	49.05	—.21	—.01	—.20
49.50	49.12	49.01	—.42	—.04	—.38
49.62	49.18	49.10	—.51	—.08	—.44
49.76	49.28	49.14	—.62	—.14	—.48

4730	4731	1094	1094 minus 4730	1094 minus 4731	4731 minus 4730
°	°	°	°	°	°
		12 hours and 13 minutes.			
49.78	49.42	49.17	—.61	—.25	—.36
49.85	*49.52	49.21	—.64	—.31	—.33
49.88	49.68	49.25	—.63	—.43	—.20
49.90	49.70	*49.30	—.60	—.40	—.20
49.94	49.80	49.44	—.50	—.36	—.14
49.96	49.86	49.68	—.28	—.18	—.10
49.98	49.90	49.76	—.22	—.14	—.08
50.00	49.95	49.82	—.18	—.13	—.05
50.01	49.95	49.86	—.15	—.09	—.06
50.01	40.86	49.92	—.09	+.06	—.15
50.03	49.98	49.94	—.09	—.04	—.05
50.06	49.99	49.96	—.10	—.03	—.07
50.10	50.02	50.00	—.10	—.02	—.08
50.13	50.03	50.02	—.11	—.01	—.10
50.16	50.04	50.02	—.14	—.02	—.12
50.22	50.08	50.04	—.18	—.04	—.14
50.28	50.13	50.05	—.23	—.08	—.15
50.30	50.18	50.06	—.24	—.12	—.12
*50.42	50.20	50.08	—.32	—.12	—.22
50.75	50.24	50.08	—.67	—.16	—.51
50.78	*50.50	50.12	—.66	—.38	—.28
50.80	50.55	50.18	—.62	—.37	—.25
			Means by Cycles.		
			°	°	°
			—.33	—.13	—.17
			—.29	—.17	—.18
			—.31	—.12	—.15
			—.36	—.16	—.18
			—.30	—.13	—.17
			—.32		
			—.34		
			—.33		
		Means.	—.32	—.14	—.17

An examination of the residuals in these series shows that if the corrections given in the preceding table are applied to the observed readings, the magnitude of the deviations will be reduced by a little less than one-half of their entire amount. We must therefore conclude either that the tabular corrections were not those actually required in these observations, or that other causes entered into their formation besides that due to personal equation in estimating the subdivisions of the scale.

WATERVILLE, ME., January 22, 1890.



TORNADOES IN MARYLAND, VIRGINIA AND WEST VIRGINIA.

STATE TORNADO CHARTS.—MARYLAND.

By LIEUT. JNO. P. FINLEY, Signal Service, U. S. A.

TABLE I.—*Tornadoes in Maryland.*

Period of observation, 75 years,—1814–1888.

Total number of storms,—31.

Year of greatest frequency, 1888,—11 storms.

Average yearly frequency,—2.5 storms.

Year in past (10) ten years, no report of storms,—1880, 1881, 1882, 1883 and 1884.

Month of greatest frequency, August,—15 storms.

Day of greatest frequency, August 21st,—8 storms.

Hour of greatest frequency,—3 to 4 P. M.

Month without storms,—January, March, April, November and December.

Prevailing direction of storm movement,—NE.

Region of maximum storm frequency,—northeast portion.

TABLE II.— *A Chronological Table showing the location, date and time of occurrence and general character of formation and movement of Tornadoes in the State of Maryland, for a period of 75 years, from 1814 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
District of Columbia	August 25.	1814	Afternoon.	NE.	Funnel.	Narrow.
Cecil	.....	1833	.....	NE.	.....	300.
Baltimore	May 22.	1838	7 p. m.	NE.	.....	.....
Carroll	July 4.	1874	.....	.....	.....	.....
Harford	October 6.	1875	3:45 p. m.	NE.	Funnel.	.....
Calvert	February 27.	1876	6:20 p. m.	NE.	.....	.....
Baltimore	July 3.	1877	.....	.....	.....	.....
Garrett	"	1877	.....	.....	.....	.....
Anne Arundell	August 10.	1878	4 p. m.	NE.	.....	.....
Baltimore	June 28.	1879	.....	NE.	.....	.....
Montgomery	September 3.	1879	6 p. m.	NNE.	Inverted funnel.	90 to 300.
Harford	August 3.	1885	Afternoon.	N6.	Funnel.	.....
Cecil	"	1885	6 p. m.	NE.	"	.....
Baltimore	"	1885	5:20 p. m.	NE.	"	.....
Cecil	"	1885	12 m.	N 12° E.	"	300 to 600.
Dorchester	"	1885	7 p. m.	NE.	"	60.
Baltimore	July 15.	1886	7:15 p. m.	N. 10° E.	Balloon.	150.
Frederick	February 15.	1887	1:15 p. m.	NE.	Funnel.	Narrow.
Carroll	July 17.	1887	4 p. m.	SE.	"	"
Baltimore	"	1887	3 to 4 p. m.	NE.	"	"
Cecil	August 21.	1888	4:30 p. m.	NE.	"	600.
Kent	"	1888	"	NE.	"	1,320.
Anne Arundell	"	1888	2:30 p. m	NE.	"	100.
Anne Arundell	"	1888	Evening.	NE.	"	800.
Carroll	"	1888	5 p. m.	NE.	"	900.
Prince George	"	1888	3 p. m.	NE.	"	Narrow.
Kent	"	1888	4 p. m.	NE.	"	"
Kent	"	1888	"	Easterly.	"	2,640.
Prince George	September 14.	1888	Evening.	NE.	.....	1,320.
District of Columbia	September 16.	1888	3:30 p m.	NE.	Funnel.	200.
Frederick	October 19.	1888	6:05.	Easterly.	"	4,500.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Maryland.*
The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
February	11 and 27	3	2
May	22	1	1
June	28	1	1
July	(3)^2, 4, 15 and (17)^2	4	6
August	(3)^5, 10, (21)^8 and 25	4	15
September	3, 14 and 16	3	3
October	6 and 19	2	2
(—) Blank	(—)	1	1
Total		19	31

NOTE.—The (—) signifies date missing.

STATE TORNADO CHARTS.—VIRGINIA AND WEST VIRGINIA.

By LIEUT. JNO. P. FINLEY, SIGNAL SERVICE, U. S. A.

TABLE I.—*Tornadoes in Virginia.*

Period of observation, 75 years,—1814–1888.

Total number of storms,—29.

Year of greatest frequency, 1888,—7 storms.

Average yearly frequency,—2.2 storms.

Year in past ten (10) years, no report of storms, 1879 to 1885, inclusive.

Month of greatest frequency, September—9 storms.

Day of greatest frequency, September 10th,—3 storms.

Hour of greatest frequency,—Afternoon.

Months without storms,—January, February, October, November and December.

Prevailing direction of storm movement,—NE.

Region of maximum storm frequency,—southeast portion.

TABLE I.—*Tornadoes in West Virginia.*

Period of observation, 9 years, 1880–1888.

Total number of storms,—14.

Year of greatest frequency, 1887,—12 storms.

Average yearly frequency,—4.7 storms.

Year in past ten (10) years, no report of storms,—1879, 1881, 1882, 1883, 1884, 1885 and 1888.

Month of greatest frequency, March,—6 storms.

Day of greatest frequency, March 24th,—6 storms.

Hour of greatest frequency,—5 to 6 P. M.

Months without storms,—January, May, September, October, November and December.

Prevailing direction of storm movement,—NE.

Region of maximum storm frequency,—eastern portion.

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of Virginia for a period of 75 years, from 1814 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Loudon	August 25.	1814	Afternoon.	NE.	Funnel.	
Henrico	July 27.	1816				
Isle of Wight	May 16.	1834		E. 10° S.		150.
James City	June 21.	1834				
Cumberland	March 4.	1842				
Isle of Wight	March 19.	1857	2:30 a. m.	N.		300.
Smith	June 25.	1874				
Norfolk	August 23.	1875				
Nottoway	July 13.	1876	Afternoon.	NE.		
Norfolk	"	1876	"	NE.		
Southampton	May 26.	1878	4 p. m.	NE.	Cone.	450 to 600.
Dinwiddy	September 12	1878	1:20 p. m.	SE.	Funnel.	40 to 300.
Hanover	"	1878	Afternoon.	NE.		375.
Dinwiddy	"	1878	"	NE.	Funnel.	40 to 300.
Goochland	"	1878	4 p. m.	SE.	Inverted cone.	300 to 700.
Rockingham	June 25.	1881	Afternoon.	NE.		3,000 to 6,000.
Lunenburgh	July 18.	1886	"			
Accomack	July 23.	1886	"	NE.	Waterspout.	
Accomack	September 12.	1886	8 p. m.	NE.	Funnel.	40 to 250.
Nausemond	April 18	1887	6:30 p. m.	NE.	"	300 to 600.
Nottoway and Amelia	June 21.	1887	Evening.	NE.		2,640.
Wythe	July 23.	1887	8:45 p. m.	NE.	Funnel.	1,320.
Nausemond	May 31.	1888	4 p. m.	NE.	"	900 to 1,320.
Fauquier	July 8.	1888	9:30 p. m.	Easterly.		2,640.
Rockingham	August 12.	1888	Evening.	"	Cone.	1,320.
Nausemond	September 10	1888	Afternoon.	ENE.	Funnel.	800.
Isle of Wight	"	1888	"	NE.	"	300 to 600.
Southampton	" "	1888	"	E.	"	1,320.
Orange	September 20.	1888	4 p. m.	NE.	"	Narrow.

TABLE III.— *Relative frequency of Tornadoes by months and days, for Virginia.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
March	4 and 19	2	2
April	18	1	1
May	16, 26 and 31	3	3
June	$(21)^1$ and $(25)^2$	2	4
July	8, $(13)^2$, 18, $(23)^2$ and 27	5	7
August	12, 23 and 25	3	3
September	$(10)^3$, $(12)^5$ and 20	3	9
Total		19	29

TABLE II.—*A Chronological Table, showing the location, date and time of occurrence, and general character of formation and movement of Tornadoes in the State of West Virginia for a period of 9 years, from 1880 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Ohio	April 16.	1880	Afternoon.	.....	.....	.....
Cabell	June 13.	1886	5 p. m.	E.	Funnel.	1,320.
Cabell	February 26.	1887	5 p. m.	NE.	.....	.....
Jackson	March 24.	1887	4:30 p. m.	NE.	Funnel.	.....
Wetzel	"	1887	6:30 p. m.	NE.	.....	.....
Mason	"	1887	5 p m.	NE.	Funnel.	Narrow.
Cabell	"	1887	5 p. m.	NE.	"	"
Tyler	"	1887	6 p. m.	NE.	.....	"
Ohio	"	1887	5:30 p. m.	NE.	Funnel.	"
Cabell	June 1	1887	7 p. m.	NE.	.....	5,280.
Kanawha	June 5.	1887	Evening.	NE.	Funnel.	Narrow.
Wood	July 20.	1887	"	NE.	"	2,640.
Wood and Wirt	"	1887	"	NE.	"	2,640.
Kanawha	August 2.	1887	"	Easterly.	.....	1,320.

TABLE III.—*Relative frequency of Tornadoes by months and days, for West Virginia.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
February	26	1	1
March	$(24)^6$	1	6
April	16	1	1
June	1, 5 and 13	3	3
July	$(20)^2$	1	2
August	2	1	1
Total	.....	8	14

WEYHER'S EXPERIMENTS ON WHIRLWINDS, WATERSPOUTS, STORMS AND REVOLVING SPHERES.*

By Prof. E. Mascart.

A sheet iron basin 70 cm. in diameter and 6 cm. in depth is inserted in the bottom of a box, three sides of which are covered with some dark material, and the fourth side made of glass so that the entire height of the case is open to inspection. (See Fig. 1). The case is 100 cm. square and 120 cm. high. It is completely open at the top, and has a supporting cross bar, in the middle of which is a socket supporting the shaft of a horizontal disc 20 cm. in diameter. This disc which is 150 cm. from the basin is a simple card board drum open at the bottom, with radial paddles, and by means of belting, is made to rotate from 500 to 1,500 times per minute. We begin by placing in the basin boiling water, and then rotate the disc. The air at the centre is forced to the circumference and forms a vertical whirl which spreads gradually to the bottom. After a few

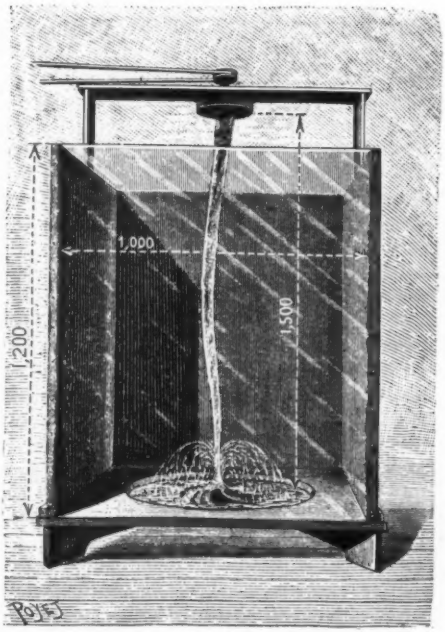


Fig. 1.

*Translated by Mr. A. McAdie from the *Journal de Physique*, December, 1889.

moments the surface of the water is covered with small spiral ripples surrounding a small protuberance or elevation of water formed in the axis of the aerial whirl. The evaporation from the surface of the water takes also a centripetal movement and the vapor moves around the axis, suddenly rising in a well defined spindle, the entire height of the case between the surface of the water and the disc. This white spindle constitutes a true tube, in the interior of which can be seen, from top to bottom, a sort of core, which is quite marked, presenting the appearance of a lengthened cone, the apex of which is at the water surface. In reality the whirl is neither fixed nor perfectly vertical but inclines more or less owing to numerous small eddies. After a few moments and when the water is less warm, the excess of vapor obstructs the ascending and descending aerial spirals, and swellings are then seen ascending and descending the misty spindle. The disc in fact, acts as a ventilator, or as a kind of centrifugal pump, forcing the air from the centre to the circumference—and if we connected a manometer tube to the centre of the disc, a lessening of the pressure would be shown. The lessening exists in the same degree throughout the entire length of the nebulous tube. If we bring the manometer tube down further to the foot of the whirl, every time we get a coincidence with the axis of the whirl, the manometer indicates the same decrease of pressure as when at the top.

We next place a small rubber air balloon, from 5 to 6 cm. in diameter, in the case. The balloon falls to the surface of the water, where it comes under the influence of the whirling, and is quickly sucked into the vortex. The spindle of vapor seizes it, as if it would engraft it, making it revolve, until finally the spout raises the balloon, with a twisting motion, and keeps it more or less elevated. When the balloon is spherical and well centered, it will often follow the spout up to the disc where it is forced out to the edge, to fall to the bottom of the case, to begin again. The spout therefore has an ascensional effect, or at least; an ascending movement predominates, because of both the diminished pressure and the rotation; but we shall see that there is also a descending effect. This has been already indi-

cated in the swells which rose and fell, according as they were formed by the excess of ascending or descending vapor. We should note too, that often the nebulous spindle was formed of a double envelope of vapor, two concentric tubes, the particles of which revolved in the same direction, but with opposite circulation as regards height. Before going further it may be proper to remark that the box with glass has nothing to do with the production of these phenomena. It serves simply to keep out currents of air and give permanence to the experiment. Indeed these experiments have succeeded in open air and on a larger scale. The height here was three meters, and the diameter five meters. (See Fig. 2.) For that matter, we could obtain just as well, a spout 50 meters high. It is only a question of expense and locality. Finally it may not be amiss to say that the experiment succeeds just as well when the disc has in addition to its rotational movement, a horizontal displacement. The spout then follows the disc and travels over the water surface. We will observe, however, that we form our spout with vapor rising from the surface of the water, while in nature, the spout proceeds from above and descends from the clouds, and consequently the objection could be raised that the experiment did not imitate natural conditions. We proceed to

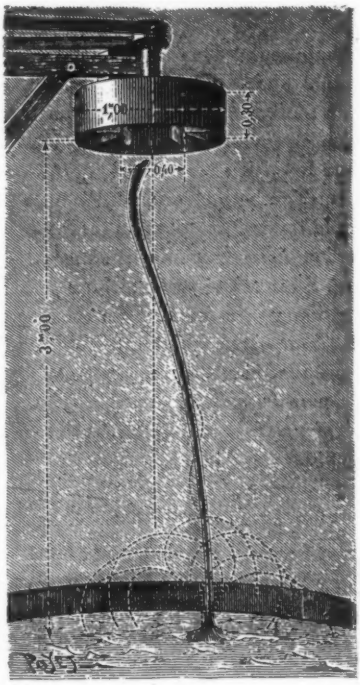


FIG. 2.

show that the objection is not valid—and that if we take the vapor from below it is only because this is most convenient for us. If we cool the water, so that the quantity of vapor is decreased, the nebulous spindle is still visible and its bottom shown still on the surface of the water by a small central elevation. If, between the disc and the basin we create an artificial cloud, either by means of vapor from a tube connected with an exterior boiler, or more simply by holding near the course of the spout, a small piece of charcoal fixed on the end of a cane giving abundant smoke, (Fig. 3) we shall see the vapor or smoke begin to be affected in the whirl; part going upwards, part downwards—to the interior of the spindle of vapor, forming a pointed cone, often in contact with the surface of the water. This can be readily explained if we consider that the disc acts as a centrifugal pump, the column of vapor being the aspirator, closed besides at the bottom by the water. In the interior of this tube, the pressure is less than that of the circumjacent air. The smoke therefore tends to fill the empty interior and will descend in filling it to the surface of the water. In this experiment we have kept the water somewhat warm, so that the motion of the descending smoke opposed to the vapor motion, might be more easily traced. If we entirely cool the water, or empty the basin, the aerial waterspout is then invisible; however, if we present the smoking charcoal near the track of the spout, we see some of the smoke ascend towards the disc, and some of it fall to the bottom in a sharp cone, the apex of which

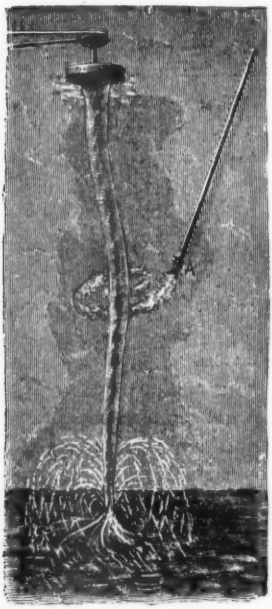


FIG. 3.

sometimes touches the bottom of the basin. Sometimes the point has a vertical oscillation, approaching and receding from the ground, exactly as in a natural waterspout. We must note too that the smoke, revolving around the spout after leaving the end of the cane, acquires a velocity more and more accelerated, from the point of origin *A* to the point where its velocity is a maximum. We can see from these experiments that a waterspout has the double property of carrying up and bringing down objects met with in its course. To make this still more evident, suppose we remove the water altogether from the basin and placeat its centre a small sponge soaked with ammonia. We start the disc rotating and present about half way up another sponge soaked with hydrochloric acid. Immediately the two gases unite to form ammonium chlorhydrate in the spindle of the spout. Figure 4 shows still another way to produce a spindle of vapor, twisting into a spout and having a rapid rotary movement. This experiment often succeeds in a work room warmed by small furnaces raised on legs a slight distance from the ground, and when the air is not disturbed. The damp

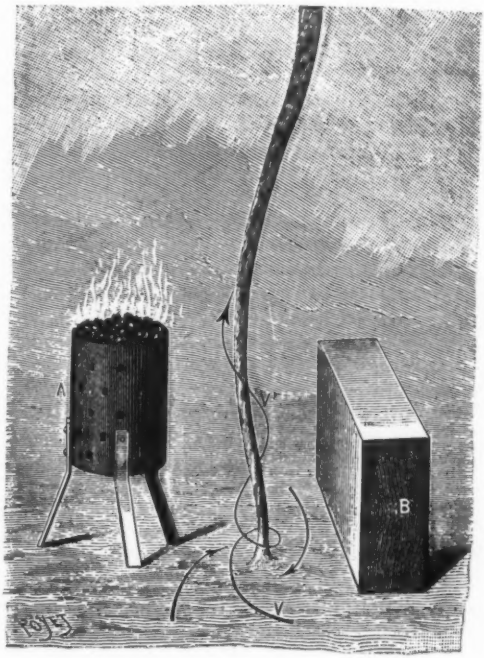


FIG 4.

ground, warmed by radiation, sends off certain vapors, while the products of combustion projected vertically into the air above the furnace, being less dense from *an elevated* region in which the *pressure* is *less* than *that* of the circumjacent air hold their place in the middle of the surrounding air. This is why the vapors move horizontally over the ground to a common centre, from whence they rapidly rise revolving in a circle of from 3 to 4 cm. diameter, and to a height of perhaps two or three metres. The experiment succeeds even better if we place in the neighborhood of the furnace a block like *B*. If we place 50 or 60 small air balloons on the dried basin, and start the disc rotating, we see the balloons driven towards the centre and knocking against each other. Those which reach the axis of the spout are immediately sucked up to the top, forced out again to the circumference, to fall again and recommence their course. The paths taken by the balloons are always centripetal spirals at the bottom and centrifugal spirals at the top as soon as they have passed into the centre of the whirl.

If we place soapy water in the basin we can see the formation of the tree-like column. Experimenting on a larger scale we can obtain it directly with water, and in the open air this tree may reach large proportions. The spray of the water rises in a heap around the spout; most of the spray falls back again, but some of it follows the ascending curves and reaches the disc. To do the experiment on a small scale successfully, air should be forced into the soap suds by means of a perforated tube. The spout is then seen to draw in all the bubbles to its center and raise many to the top, when they fall outside. This is also just what happens in the natural spout, which may raise to the clouds large quantities of water (even small fish), which fall again as rain, at a distance more or less great.

The double centrifugal and centripetal motion is shown still more clearly by placing a little meal in a glass cylinder, the upper cover of which is crossed by the axis of a small disc rotating in the interior of the cylinder. We begin by giving to the meal the form of a cone or nipple, the point of which is turned upwards. As soon as the disc is rotated a small wreath is seen

to form at the top of the meal. Little by little the meal is hollowed out, and we can see the centripetal whirlings on the surface, a constant flow of material to the center, where it rises, and is finally thrown out towards the circumference to return to the center and so on again.

A vertical projection of the meal thus in motion would resemble the *Dumb-bell* nebula. An experiment rather difficult to show publicly because it requires time, consists in placing in the focus of the spout the bulb of a thermometer. A rise in temperature of several degrees is shown. The particles driven to the center collide with one another, and thus cause a rise in temperature. If, with the reduced velocity of our aerial whirl we get an increase of several degrees of temperature, we can conceive that at a certain velocity there would be fusion of these particles colliding with one another, and a great increase of temperature. Considerations which we need not here go into show that the body thus formed at the focus of the whirl would be a sphere. To demonstrate this, the apparatus shown in Fig. 5 has been devised. A glass cylinder is filled with a mixture of sand, fine plaster and sawdust. The bottom of the case is pierced by a small glass tube carrying a wick of blotting paper. The tube is connected with a bottle containing gummy water.

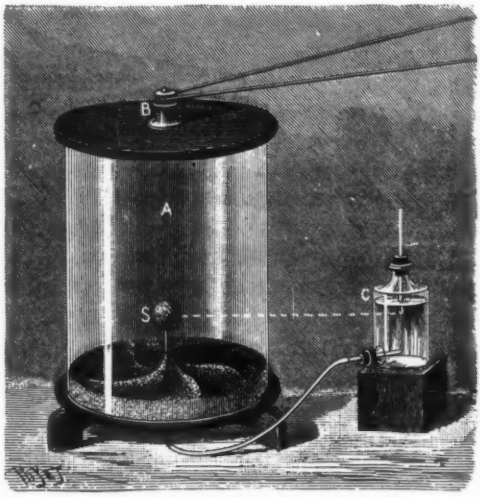


FIG. 5.

After the disc has been rotated for about a half hour the small particles of plaster have passed into the focus occupied by the damp wick and gathering together produce a sphere of a very perfect form considering the coarseness of the material used and the imperfection of the apparatus.

Keeping the disc revolving, let us place under it a horizontal plate or piece of glass. Upon this we set a coin spinning. The aerial whirling continues the movement, accelerating it much, and the coin remains absolutely captive to the whirl, revolving so rapidly as to look like a sphere. If the coin were covered with a sticky substance, and the whirl could carry dust particles, they would aggregate and increase still more the dimensions of the sphere. These different experiments permit an explanation of the formation of hail which we will but mention, and about which those who are interested can obtain full information in the book "*Sur les tourbillons, trombes, tempêtes,* etc.," published by the firm of Gauthier-Villars.*

Having removed the meal and started a rotating system of two small squares of tin, we place in the cylinder a small piece of smoking charcoal. The smoke immediately concentrates in the whirl, and as the smoke is excessive, we soon see the swellings ascending and descending the length of the spindle. Soon the whole apparatus is filled with smoke—but the black axis can always be discerned amid all the whitish smoke. Finally, another curious experiment, but visible only to those near by, consists in introducing into the glass cylinder a hemispherical cup in which we place some grains of meal still containing traces of flour. Setting the disc revolving, we see the larger grains move towards the circumference, while the others move to the centre in marked centripetal spirals, all leading to a small central nucleus and producing the effect of the nebula of the constellation of the *Hunting Dogs.*

Cyclone Experiment.—Let us first note, that a cyclone differs from a water-spout only in the ratio of the diameter to the height; in the latter the diameter is quite small compared with the height, while in the cyclone the diameter is great compared

* Quai des Grands-Augustins, 55, Paris.

with the height. But the motion of the air is the same in both; descending from the exterior to flow in and rise again in the centre, only in the case of the cyclone, because of the greater diameter, the air begins to re-ascend before reaching the center, so that we generally find in the center a characteristic calm region. We may also notice that in a fog descending on the sea, there is a central part free from vapor, so marked that even when the weather is stormy, on all sides this central part is clear and calm, and the sun shines clearly. This is the so-called eye of the storm. We can add further, that since this interior nucleus is free from vapor, the humidity is less there than else-

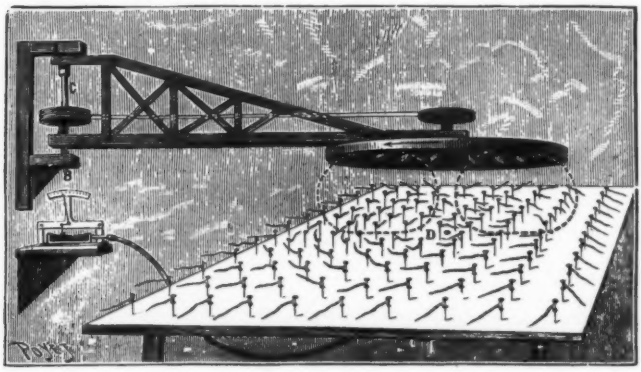


FIG. 6.

where around it. This has been noticed to be the case in natural cyclones. This is the experiment: On a table two meters long and one meter wide, are fastened two hundred pins, to the heads of which are fastened small light woolen streamers. (See Fig. 6.) We may picture these as representing the pennants of so many ships at sea. The table is pierced in its centre so that connection may be made with a manometer tube. This might be considered as a ship provided with a pressure gauge. Above the table 25 or 30 cms., is a large flat disc, 80 cms. in diameter, provided with blades radially arranged. This is mounted on a hinged frame of 1.5 meters radius, and the disc

having a rotary motion communicated to its air whirl can be made to move horizontally over the table. We begin by placing the disc over a certain part of the table and setting it to rotate. We at once perceive that the woolen fibres indicate the direction of the wind at each point. The interior rows show a slight centripetal motion, the exterior rows however showing plainly a centrifugal motion. The little woolen streamers close to the centre are seen to lie quietly on the table. These show the central calm. If now we make the cyclone travel slowly

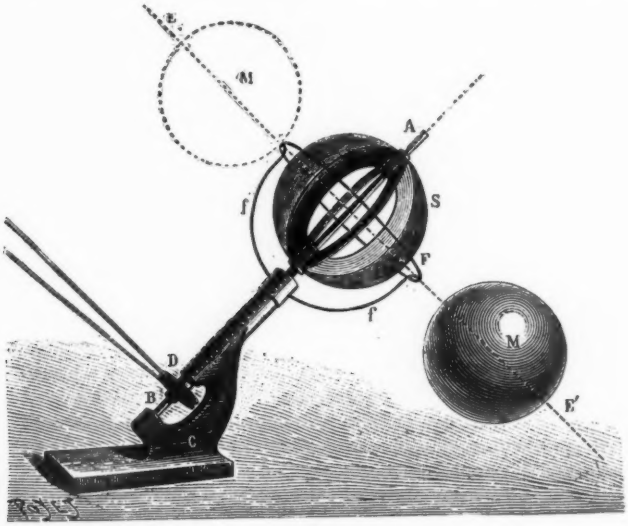


FIG. 7.

above the table by rotating the supporting frame on its hinge the cyclone begins to make its action felt, above the hole pierced in the table, which communicates with the manometer. This will show a diminished pressure which becomes a minimum when the centre of the whirling disc is just above the hole, and as we push the disc past to the opposite side, the pressure increases again to the initial value. We notice also that around the central calm the pennants on the right are pointing, for ex-

ample, from north to south, while on the left they seem to blow from south to north. The very moment one of these streamers gets out of the influence of the central calm, we notice the rapid change which occurs on leaving the calm, and the pennant which a moment before pointed northward, quickly reverses its direction and now points towards the south. To show the central calm at a distance, we place on the table a sheet of cardboard a little larger that the disc, and carrying twenty-five or thirty tips of candles lighted. We place the disc above the cardboard in such a way that the central candle is just below the centre of the disc, and we start it rotating. We see the draught blow out all the candles except the one in the centre, which continues to burn tranquilly.

Revolving Spheres.—The attentive study of the simple whirls leads inevitably to the consideration of those around a sphere rotating on its polar axis. Let us form a sphere by meridianal sections (Fig. 7). It is really an aspirator, drawing in air at the polar regions and expelling it at the equator. If we scatter little pieces of paper in this equatorial region they are immediately driven away, but if we offer to this equatorial draft balloons of proper dimensions and densities, not only are the balloons not forced off, but on the contrary they are attracted to the revolving sphere and describe orbits around it in the plane of the equator, whatever its direction with regard to the horizon may be. The movement communicated by the revolving sphere to the air is propagated some distance into the room and

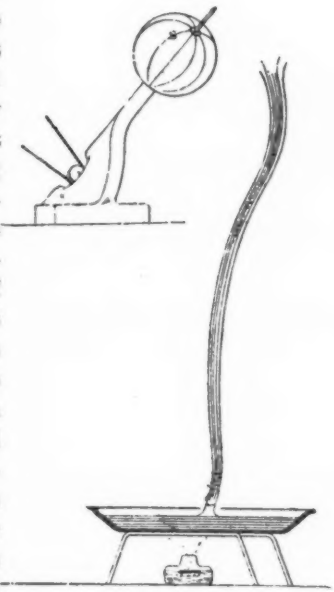


FIG. 8.

balloons trailing on the floor acquire a motion of rotation and every body within the area where the influence of the rotating sphere is appreciable is carried to it by a whirl. The following experiment shows this (Fig. 8): If we place the basin containing the boiling water on the ground, we see the vapor concentrate in a spout, as in the first experiment. The spout leaving the basin is directed toward the sphere's equator. A small and light balloon placed on the surface of the water would be elevated by the spout and drawn into the sphere. The foggy spindle ends at the equator and not at the pole as would seem natural. The following experiment shows the reason why the equator is the region of maximum spouts, and a short consid-

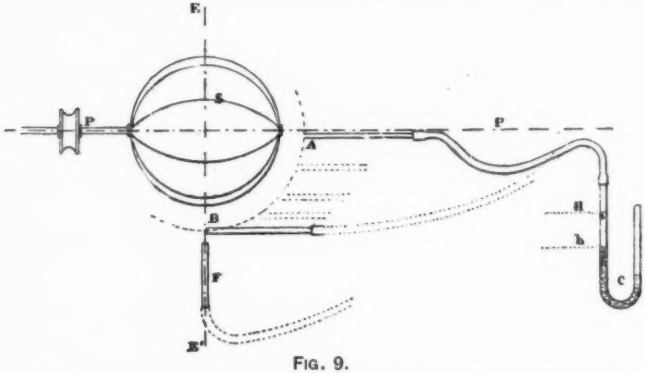


FIG. 9.

eration would lead to the same conclusion. Let us connect a copper tube with the rubber tube attached to the manometer already mentioned. The end of the copper tube is flattened out like a whistle, to form a narrow slit; when this is placed near one of the poles the manometer shows a depression. (Fig. 9.) If, however, we gently carry the extremity of the tube towards the equator we notice a constant diminution of the pressure until we have a minimum when just over the equator. Thus far we have placed the slit perpendicular to the plane of the equator; but if we now place it in the plane of the equator, the manometer indication is immediately reversed and shows an increased pressure, because the equatorial out-draft is forced directly into

the tube. The whirls that exist on the sides of the equatorial draft cannot now exert any influence because they escape to the right and left of the lips of the tube. This experiment explains why it is that balloons of proper dimensions are attracted to the equator rather than elsewhere, and also why the vapor spindle tends towards the equator instead of seeking the pole nearer the ground, as one might naturally think would be the case.

TROMBES AND TORNADOES.

By H. Faye,
Membre de l'Institut, President du Bureau des Longitudes, etc.

(CONTINUED FROM APRIL NUMBER.)

New Theory of the Meteorologists.—This discussion has had at least one result: that of calling the attention of meteorologists to the incontestable point that in attributing the origin of *trombes* and tornadoes to the character of the surface, it becomes impossible to explain their double movement of gyration and translation. In this originates the remarkable evolution which has taken place within the last years in the minds and doctrines of some masters of the science of meteorology. The following is what is said on this subject by Mr. E. Douglas Archibald, in *Nature*, June 14, 1888:

"M. Faye postulates two points: 1st, that the movement begins above; 2d, that it is propagated downward by a descending motion, accompanied by gyration around a vertical axis. The opposed theory as presented by M. Faye,* is the exact inverse of this: since it makes the action, 1st, commence at the earth's surface; 2d, propagates itself upwards; and 3d, borrow its gyration from that of the earth. Here, however, we find ourselves distinctly at issue with M. Faye, for we do not believe that the leaders of modern meteorology entertain any such view as the latter. The surface of the earth is the most unlikely birth-place for a tornado, whirlwind or waterspout. In order to maintain an ascending current the air must be nearly satu-

* Mr. Archibald should have said: as presented by the meteorologist.

rated, and this will generally occur only in and near the lowest cloud stratum. The vertical temperature gradient and disturbances which start the action will likewise operate most effectively at this level, so that all the conditions which unite to cause a tornado will tend to commence at some distance above the earth's surface. On the question of level, therefore, we may invite M. Faye to agree with us."

It is a great point to have at least recognized that the origin of this phenomena should be sought in the upper currents of the atmosphere. There only can be found rapid currents capable of transporting tornadoes over regular trajectories with the swiftness of express trains. There also may be found the force capable of producing below, when transmitted to the surface by descending gyration, the frightful work of tornadoes But the authors of this new theory hold, above all, to the prejudice which I have just combated; like their predecessors they want aspiring *trombes.* Nothing then should descend in these *trombes;* if the gyrations originate above and propagate themselves downwards, it is not the air drawn in during these gyrations which descends, it is the gyratory movement alone, which propagates from above downwards, in causing the air of successive strata to turn, in communicating itself from one stratum to another, without displacing vertically a single molecule. Imagine a pile formed of flat disks, like pieces of money, and communicate to the uppermost a movement of rotation. This movement will be transmitted a little from one disk to another until the lowest, and you will have a conception of this theory, but this does not constitute a whirl; the air moves upon helicoidal spirals, and not upon circles which are perpendicular to a common axis. This last case corresponds to a simple rotation. A whirl, as conceived by Franklin, and as we conceive it to-day, is necessarily ascending or descending with the air or liquid which has been drawn into its circle of action.

In all these theories, in which it is a question of tornado or cyclone, the movement of translation is always forgotten; if that is taken into account, it will be easily seen that this singular transmission of gyration from above downwards, with-

out descent of the air, is incompatible with the form even of *trombes* or tornadoes. During the time that the first gyration, —by which the phenomenon begins above,—takes to communicate its action to the lower air, it has already traveled, and carried its action a little further on, upon the same stratum. It will not be then a circular gyration descending from stratum to stratum, but a series of motions extending more and more in the direction of translation. If the *trombe* takes ten seconds, taking the number at hazard, to descend to the ground, its lower extremity, instead of being clearly circular, spreads over all the space which will have been traversed during these ten seconds. But I will let Mr. Douglas Archibald tell the story:

"The entire gist of the question appears to us to lie in this downward propagation. The physical theory developed by Ferrel and Sprung makes the action commence in a slight upward motion in unstable air, due to a temperature inequality or some other cause, the only other condition being a gentle gyratory motion relative to some central point which is never wanting in a cyclonic area. Once the motion is started, and the air which feeds it is nearly or quite saturated, the action will go on and be propagated downwards, not by a descent of the *air*, but by the transference of the physical conditions which favor the continuance and maximum development of the ascending current. The increasing rapidity of gyration of the air as it approaches the axis, however it may be at starting, only allows it to partially feed the initial and continually reproduced vacuum, which is thus compelled to draw its supply chiefly from the non-gyrating air at the lower end of the aerial draft. As this is drawn upwards, the centrally aspired surrounding air is made to gyrate more rapidly (partly by friction of the superjacent rotating layer), and thus the gyratory and other conditions are propagated downwards until a balance is struck between the supply and demand. The theory thus sketched may be termed the modern theory of aspiration applied to tornadoes, and will, we venture to say, be found to meet all M. Faye's objections to the first crude notions which prevailed in past years from a study of a few isolated surface indications."

What is most interesting in this theory is the idea of a vacuum which tends to form around the axis in these gyrations, but to this is added that this vacuum aspires air only by the lower extremity of the whirling column. This strange assertion is evidently dictated by the preconceived idea of an ascending motion. But that is not at all modern; it is Franklin's theory, comprising the assertion that the internal column of the vacuum cannot aspire the surrounding air except at one end—the lower. This vacuum really tends to form, but as it begins above, it fills from above as it forms, in such a way that the internal cylinder of the tornado, like that of a cyclone, is constantly filled to the lower end by air which does not participate in the gyration and could not consequently pump from below the water of the ocean to transport it to the clouds.

Mr. Archibald has interpreted faithfully the opinion of Mr. Ferrel, for this is what I find in his (Ferrel's) remarkable "Popular Essays." "On account of the centrifugal force arising from the rapid gyration near the center of a tornado, it must frequently be nearly a vacuum. Hence, when a tornado passes over a building the exterior pressure is in a great measure suddenly removed, when the atmosphere within, not being able to escape at once, exerts a pressure upon the interior of perhaps nearly fifteen pounds to the square inch, which causes the parts to be thrown in every direction to a great distance. For the same reason, also, the corks fly from empty bottles, and everything with air confined within, explodes. . . . As the imperfect vacuum of the center of the tornado reaches the sea, the water has a tendency to ascend to a certain height, and thence the rapidly ascending spiral motion of the atmosphere carries the spray upward, until it joins the cloud above, when the waterspout is complete."

"The indrawing, gyratory and ascensional currents are so strong as to draw in and carry up very heavy bodies and throw them out above to a great distance. Sometimes the ascending current is so strong as to keep a heavy body suspended in the air for a long time until the tornado has progressed many miles,

when, after the violence of the tornado begins to abate, the body falls to the earth."

Here we are again in the midst of Dampier's ideas. Meteorologists may well change their system, and place the seat of aspiration in the clouds like the old navigators, below with Espy, above again with Messrs. Ferrel, Sprung and Douglas Archibald; the leading idea is always that *trombes* pump water from the ocean to the clouds. Now, when the stories of these pretended phenomena are examined without prejudice, it is found that there is at the bottom only a vague appreciation, impressions misinterpreted by incompetent witnesses, or material impossibilities. It is found that *trombes* and tornadoes pump nothing at all: they act on the land or on sea only by their formidable gyrations. And exactly apropos of these familiar assertions, I will cite the conclusions of a judge of whose competence and impartiality no one can doubt—I speak of Mr. Finley. In his investigations of the thirteen tornadoes of the 29th and 30th of May, 1879, in the United States, Mr. Finley, having learned by ocular witnesses that, in passing over Salt River, one of these tornadoes had pumped the water from it so as to leave the river bed dry, he searched with care to see if the water had been deposited farther on in the track of the storm. He found no trace of it and concludes as follows: "The tornado cannot have pumped much, if any; but by the action of its terrible gyrations it must have driven the water from one side to the other of the river, so that the bed of the river was left dry for an instant, as happened on the Big Blue at Irving."

It is the same work that the waterspouts, ordinarily less powerful, execute by their gyrations in agitating circularly a large extent of water, and in projecting to a distance around them tangentially to their base masses of water and foam, to which mariners have given the name *buisson*.

It may be objected that other observers here have been more successful than Mr. Finley, and have found, at a distance, significant traces of masses of water, which *trombes* have raised and transported. Mr. Espy, having some reasons for supposing that the great tornado of Hollidaysburg, Pa., June 19, 1838,

transported to a distance a large quantity of water, went immediately to the locality visited by this phenomenon, and found against the flanks of the hills, which must have arrested its progress, excavations eight or ten meters in diameter and from one to two meters in depth, which he did not hesitate to attribute to the sudden fall of the mass of water of the tornado. It suffices to read the description of these holes or little ravines, to see that they were the work of what geologists call wild waters—*les eaux sauvages*—flowing in torrents over declivities, and leveling strata of very unequal density.

In terminating this historical part, I would call the attention of the reader to the two following considerations: 1st. Whatever may be the theory in question, it is necessary for it to assign the origin of the force which tornadoes exercise on the soil and on obstacles which they encounter.

According to the meteorologists, the source of force would be the heat due to the condensation of the vapor which the air carries in its ascension. But we see in rain and in showers, this condensation operating upon the largest scale, without producing below and around us any appreciable action.

The heat that is developed engenders various mechanical movements, but as there is nothing to concentrate them over a small space, the mechanical effects remain stationary, modifying only to a slight extent the strata of air over a vast space.

In the theory which I propose, on the contrary, the mechanical force is evident. It is that of mighty aerial rivers, of which the inequalities of velocity are stored in the great mouth of a descending whirl.

These aerial whirls have, like the whirls of our water courses, the property of concentrating below in a small space, nearly all the *vis viva* which they have borrowed from these currents.

2nd. In any theory there must first be considered the absolutely general fact, that the force which exerts itself so violently below, in unceasingly renewing itself, progresses rapidly over a long, well defined trajectory.

Now, in Espy's theory this translation is impossible. In that which Mr. Douglas Archibald has presented, this inevitable

translation supposes that the place of origin is found in the midst of an upper current. Now, here are two ideas which are irreconcilable; there must be a current above: Yes, but, if there is a current above, the unstable equilibrium, the first ascending puff of air, the first gyration which follows,—all becomes inadmissible. While in the theory which I propose, where the superior current itself engenders the whirl, it is quite simple that the whirl should follow the thread of the current as is done every day by the whirls in our water-courses. As to the difficulty of proving mathematically that these whirls are descending, that cannot stop us: the facts are there and can be verified.

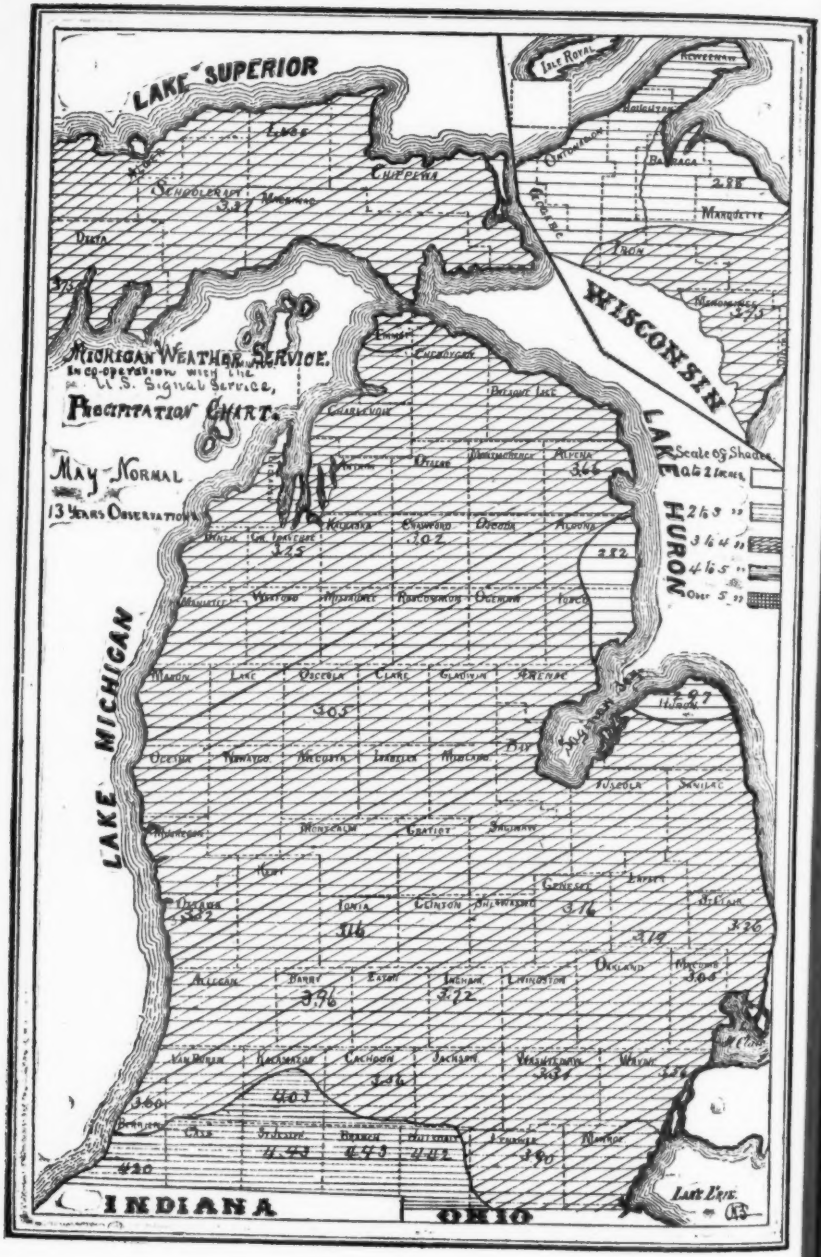
[TO BE CONTINUED.]

RAINFALL IN MICHIGAN—MAY.

By N. B. Conger.
Director State Weather Service.

With the month of May begins the wet season of the year which continues during this and the next month, and then again begins the decrease in rainfall during the summer months.

The average rainfall for May for the State is 3.40 inches, the largest amount occurring in the extreme southwest and the least in Alcona and Iosco counties. A monthly average of less than one inch has rarely occurred in the State during May, and then only in small sections, and this is only recorded in 1877, which was generally a dry month over the State, and in Lapeer county in 1881. By reference to the chart it will be noticed that in the southern tier of counties on the west and working up into Kalamazoo county is the line of four inches, which is just beginning to become apparent this month, and which in the next has increased in a northerly direction to the center of the State. The heavy rainfall in the extreme southwest portion of the State will be noticed during the entire year and readily accounts for the large annual rainfall which is generally recorded in this section. The distribution of the rainfall in the State during May, is very uneven, ranging from two to four inches in different


LAKE SUPERIOR
Isle Royal
Houghton
Ontonagon
Baraga
Marquette
Iron
Menominee
WISCONSIN
LAKE HURON
LAKE MICHIGAN
Michigan Weather Service.
In co-operation with the U.S. Signal Service,
Precipitation Chart.
May - Normal
13 Years Observations.
Scale of Shades
Less than 2 Inches
2 to 3 "
3 to 4 "
4 to 5 "
Over 5 "
Chippewa
Schoolcraft
Mackinac
Emmet
Cheboygan
Presque Isle
Charlevoix
Otsego
Montmorency
Alpena
Antrim
Kalkaska
Crawford
Oscoda
Alcona
Grand Traverse
Wexford
Missaukee
Roscommon
Ogemaw
Iosco
Manistee
Mason
Lake
Osceola
Clare
Gladwin
Arenac
Bay
Huron
Tuscola
Saginaw
Oceana
Newaygo
Mecosta
Isabella
Midland
Gratiot
Shiawassee
Genesee
Lapeer
St. Clair
Muskegon
Montcalm
Ionia
Clinton
Oakland
Macomb
Allegan
Barry
Eaton
Ingham
Livingston
Van Buren
Kalamazoo
Calhoun
Jackson
Washtenaw
Wayne
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
Monroe
Lake Erie
INDIANA
OHIO

sections, and also in contiguous territory. Probably this may be accounted for by local storms, and thunderstorms which are prevalent, and which have been the cause of the diversity of the distribution in the past three years, since the charts have been published of the rainfall for this month.

A STUDY OF CLIMATOLOGICAL INFLUENCE UPON THE RECENT EPIDEMIC OF INFLUENZA.

By R. Assmann, M. D., Berlin.*

We oftentimes hear physicians as well as patients, holding the prevailing condition of the weather accountable for a great many diseases. In the beginning and continuation of colds, especially, is this the case. Every question concerning the particulars of a cold, or the physical and physiological occurrence of the cold is almost invariably left unanswered, or is discharged with the customary phrase "I must have caught a cold." Of course there are numbers of physicians who very unwillingly confess that really little or nothing is known of the influence of climatic conditions upon disease in a strictly scientific sense. From time to time endeavors have been made to throw light upon this subject by investigations in pathology and meteorology. For this purpose there have been statistics gathered with the view of showing a relationship between the different forms of diseases and the effects of climatic elements, such as air, pressure, temperature, relative and absolute humidity, winds, etc.

On the whole, one can say of these experiments that, with few exceptions, they have been failures. The reason for this is, doubtless, that most physicians lack a preparatory knowledge of meteorology, deeming it such a simple and insignificant science, that they are inclined to believe themselves to be quite competent meteorologists, if they have heard a *collegium publicum* upon this topic during one semester, or if, as county physicians, they have kept trace of the prescribed observations with their house barometer and outdoor thermometer.

*Translated from *Das Wetter*.

Thus it happens, for instance, that the doctrine is not yet extinct of the enormous effects upon the human organism from the variability of barometrical pressure, in spite of what Hann and others have long since proved, that the greatest variation of the barometer in the course of an hour is about equal to the change of the pressure of air to which we expose ourselves if we climb a hill thirty meters high, in the same length of time.

Likewise the influence of the temperature of air as well as its changeableness in its action upon the health and life of man is doubtless overrated. Probably the greatest change of temperature to which man can expose himself, is that which the Siberian experiences in January, when he steps out of a room showing a temperature of 20° centigrade into the open air, where the temperature is lower than 50°, yet he does not "take cold," although within a few seconds he is exposed to a difference of temperature of from 70° to 80°.

On the other hand Hann has shown that, for instance, the influence of the relative humidity upon the blood pressure in the vessels of the human body is considerable and certainly not without effect, so that it would be begging the question were we to give up such researches as hopeless, and only declare that there is a casual connection between climatic elements and diseases.

The newer pathology, which in an increasing measure seems to be changing into bacteriology, opens new paths for the investigations into the influence of climatic conditions, as we recognize more and more that the atmospheric air is the abiding place of those inferior organisms which are considered the originators of disease.

While yet in the infancy of the bacteriological investigations we attributed all blame to the water and aliments which we supposed harbored all harmful bacteria and transferred them to the human body, but we have learned of late that the air passages, especially the lungs, are far more frequently the channel of ingress for germs than the stomach. Without doubt from these views the conclusion may be drawn that certain meteorological changes which take place in the atmosphere must have influence upon the quantity, the growth or propagation of the micro-

organisms existing in the air. Let us leave out of sight first of all, certain gaseous admixtures of the atmosphere as ozone or oxygen, superoxyde, nitrous acids and others, it still remains without doubt that the atmospheric precipitations must exercise a great influence upon a large number of the organisms.

According to the well known view of Aitkens, which may be considered as generally approved, the aqueous vapor needs for its condensation particles upon which the change can take place.

Every precipitation of moisture must, therefore, remove from the atmosphere immeasurable quantities of dust particles or germs, and convey them to the earth's surface in such a form that it is almost impossible for them to penetrate or enter into the human breathing organs. The long supposed purifying effects of the precipitation of moisture thereby comes forward as another important object for pathological investigation.

That the quantity of the atmospheric dust is actually very greatly reduced by the precipitation of moisture has been proved many times by Gaston Tissandier, Mascart and Conlie, and also by the author of this article. Thus Tissandier found that after dry weather the quantity of atmospheric dust was four times greater than after a rain. In Paris after a week of dry weather he found twenty-three milligrams in a cubic meter of air, and after a heavy rain only 0.25 milligrams. In the country after a dry period 3–5, and after a rain only 0.25 milligrams of dust were found.

The comparison between a large city and the country shows the ratio to be in dry weather as six to one, and after a rain as twenty-four to one. In Paris, out of a litre of rain water, Tissandier obtained from 25 to 172 milligrams of dust, and out of a litre of melted snow, 212 milligrams at the first snow fall, from a later snow fall 108 milligrams; on the tower of Notre Dame from the first snow fall he obtained 108, from a later snow fall 56 milligrams of dust; fresh fallen snow in the country was found to contain 104, later snow 48 milligrams of dust. Similar results the author obtained in Magdeburg.*

*R. Assmann. The dust in the atmosphere and its effects. Lecture given at the fifty-fifth meeting of the Association of Naturalists and Physicians at Eisennach, 1882.

It is doubtless true that among the constituent parts of atmospheric dust the quantity of the micro-organisms plays no small part, although no detailed quantitative investigations have yet been made.

At all events we may assert that particles of dust existing in the atmosphere become harmful to the human body if they penetrate the air passages, and that they exist in a much larger quantity in the air, the more rarely and imperfectly the latter is cleansed and purified by precipitations of moisture, either in frozen or fluid form. The fact shown, from the above named figures of Tissandier, that snow carries a greater amount of dust than rain, is explained thus: That the snow by dint of its larger surface goes a longer way through the air in falling than the rain drops, and shows at the same time that the atmospheric dust is not only carried to the earth's surface in the form of condensed germs, but also mechanically by the precipitation of moisture. So long as the dust, and with it all micro-organisms in the water, remain on the earth's surface, it is impossible that they again enter into the air. Just so, snow which by day generally thaws on the surface from contact with the sun's rays, and in the night is changed to an icy crust confines the dust to the earth, and in this way hinders it from penetrating the human organism.

Only when the soil is again dried can the wind effect the return of the dust into the atmosphere. The layer of snow for this reason also acts beneficially on the reduction of atmospheric dust, because while covering the ground for a longer time it confines all harmful dust-like substances to the ground and keeps the wind from distributing all such particles which in a dry condition are so easily carried off.

But not only the precipitations of moisture which comes to the earth, but also those in the shape of clouds or fogs which float like small water drops in the atmosphere, contain the dust either as their points of condensation or as a mechanically mixed substance. It is therefore probable that great masses of dust are held fast in the clouds which hereby act as filters for the atmospheric air.

To be sure the noxiousess of the dust cannot be removed by this process, since a person surrounded by clouds would be forced to inhale these dust filled water drops. But usually we do not find ourselves in the region of the clouds, but rather lower.

But in the case in which the clouds lie on the earth's surface, in the form of fogs, we inhale the water drops with the confined dust. The asserted harmful influence of dense fogs upon the breathing organs would hereby be explained.

Under a bright sky the rapid exchange of air will effect a lessening of the quantity of dust in the lower stratum of air, so that the dust will be carried to a greater height, thereby spreading over a larger space.

On the other hand, a cover of clouds catches the dust and confines it to lower elevations, retaining it and thereby shielding the stratum of air lying above the clouds from an admixture of dust.

The origin of widely spread fogs, not considering the so-called *Bodennebel* (low lying fogs), produced by nightly radiation of heat, can again be traced back to the lack of a strong vertical exchange of air. In most cases an ascending motion of air will call forth the cloud formations in greater heights, while at the same time descending air masses carry down to the earth's surface the air of the higher strata which are freer from dust. On the other hand, if a vertical motion of air is wanting the dust of the surface will accumulate in the lower strata and though clothed in fog formation cannot help being inhaled by man. Insufficient ventilation of the lower strata and fog formation will be called forth by natural causes, principally by the existence of a range of high pressure of air, a barometrical maximum, so that we have cause for the supposition that this state of the weather would be especially favorable for the accumulation of dust near the earth's surface.

Meteorological reflections lead us, therefore, to the conclusion that substances existing in the air, and which originate in the soil, must be increased in quantity, *first*, through the dryness of the soil; *secondly*, because there is a lack of snow cover;

thirdly, the fact of, or less frequent falling of, precipitations of moisture; *fourthly*, by the existence of fogs or deep lying clouds; *fifthly*, by a prevalent high barometric pressure with little vertical exchange of air.

If, with the above preliminary discussions, we venture upon the question whether it is probable that the spreading of the recent prevailing influenza epidemic is dependent on climatic influences, we must first acquaint ourselves with the progress of the epidemic.

So far as the reports are at the author's command, the prevailing disease of the respiratory, digestive and nervous organs, understood by this name influenza, was first observed in Siberia and Russia about the middle of November, 1889.

From Tobolsk, the Government of Kasan, from Moscow, Sebastopol and Petersburg the first reports of an epidemical appearance of the disease were received.

In the beginning of December the disease seemed to have spread to Galicia and Austria by way of Russian Poland, where at Krakow, Lemberg and Vienna it was quite prevalent. From the northern part of Russia the disease wandered westward, as its appearance at Abo, Gothenburg, Stockholm and Copenhagen in the first week in December clearly shows. At the same time about the second of December, the first cases in Berlin were made known. At Paris the first appearance of it was confirmed about the fifth of December. At Munich about the tenth, at Sopia, Rustchuck, Tirnowa, Magdeburg, and Dresden the outbreak of the epidemic seems not to have taken place before the twentieth of December. The first reports from London and New York and from Spain, also show that the epidemic did not appear there until the third week of December.

Naturally, the reported times of the outbreaks are much behind the actual appearances of the epidemic, as only a certain cumulation of cases in hospitals give rise to public discussion, while sickness in the family circle, may have occurred long before a report of the same would attract public attention. Not infrequently the reports concerning the condition of a place are held back by the press, from a spirit of local patriotism, while

all news from other places is made widely public. Therefore the above given dates can only be approximately recognized. In spite of this it is certain that the epidemic found it source in the Asiatic or European parts of Russia and from there spead in a westerly direction.

What period of time is necessary for the spreading of the influenza through Europe and to America cannot be ascertained, because of the aforesaid unreliable reports of the outbreak of the epidemic.

From North America especially, a direct transporting from Siberia, that is to say from the west seems very probable, as also the independent origin of the disease in the country.

Generally the almost identical time of the outbreak of the epidemic is recognized as characteristic of the influenza, so that a simultaneous origin of the same at different points and a very rapid advancement of the disease may be taken for granted.

It is therefore impossible to decide this question so long as there are no carefully prepared statistical data at hand with regard to the outbreak of the epidemic. For our present discussion it will therefore depend principally upon this, that we investigate whether the weather-history of the two last months of the year 1889 have presented in a prominent degree such climatic conditions as will be found well adapted for the development and increase of a germ in the atmosphere which excites disease.

Through the daily weather reports and charts of the German Naval Observatory we learn the following with regard to the weather conditions of Europe:

1. After the soil had been well dampened to a considerable depth by frequent precipitations of moisture during the summer and fall, including the month of October, there was an unusually long drought in November in eastern and central Europe, which in the east, especially, continued during a part of December, while in these districts the month of November generally has 40–60 mm, and December 50–70 mm of moisture through precipitation, the figures for November, 1889, remained frequently under 10 mm at most of the easterly weather stations of Ger-

many, Austria and Russia under 30 mm, and in December, especially in the east, the figures frequently indicate under 20 mm.

The following compilation of the amount of precipitation of moisture at several places which were especially afflicted with the influenza epidemic may find room here. The statements are taken from the estimates of the weather report of the Naval Observatory, and they may therefore deviate from the actual measured sums by a few millimeters.

The height of the precipitations of moisture in mm.

1889.	Moscow.	Petersburg.	Warsaw.	Lemberg.	Vienna.	Prague.	Stockholm.
Nov.	42	40	50	25	29	20	13
Dec.	13	17	9	47	55	8	10

1889.	Koenigsberg.	Copenhagen.	Berlin.	Munich.	Magdeburg.	Brussels,	Paris.
Nov.	27	10	6	56	13	21	30
Dec.	8	11	21	30	22	31	36

Although the estimates show a lack of the usual amount of precipitation of moisture, still they do not give a sufficient cause for judging the greater or less dryness of the soil, as one single heavy rain causes less moisture in the soil than frequent and lighter showers,* therefore we will only consider the following facts:

At Moscow, during the months of November and December, in twenty-nine days there was no measurable precipitation of moisture; at Petersburg in thirty-five days, and it was perfectly dry from December 1–16. At Munich there were thirty-five dry days, it being dry from November 11–26, and again from December 4–22. Lemberg had 39, Brussels 43, Paris 44, Stockholm 46, Prague 51, Vienna 36 days, without any measurable precipitation of moisture.

Everywhere there were dry periods of from fourteen to eighteen days' duration during the second half of November, and the middle of December. Doubtless, during these times of dryness, by the failure of the precipitation of moisture and the drying out of the earth's surface, the amount of dust admixture with the air had become highly disagreeable, in some places more than others, and at a very unusual time of the year.

* The monthly figures can therefore easily give rise to false conclusions. Unfortunately for lack of space we must here abstain from giving the returns of the daily precipitation of moisture.

(TO BE CONTINUED.)

CORRESPONDENCE.

THE DECADE SYSTEM OF TIME DIVISIONS.

To the Editors:—I would like to introduce to the congress of your readers the subject of a more perfect, scientific and convenient system of time divisions, for use when compiling meteorological data. The present barbarous division into months, of unequal length, and shifting weeks is entirely unsuitable. Months are too long for derived averages and normals to be of much value, particularly in the fall and spring when the seasons are changing rapidly. For instance I find the normal daily mean temperature for the first day of April to be 44 and for the last 57 while the monthly normal is 51. Here is a departure of six and seven degrees from the monthly average, which is more than can be safely neglected. I am advocating the division of the year into decades beginning March 1st, and running thirty-seven periods, of ten days each, through the year. If commenced then, the end of each period falls on the same day of the month from year to year. I have reduced the more important elements, under this system, on this station, and am delighted with the result. The advantages are, (in part, there are too many to enumerate all): easy additions of only ten entries; averages by pointing; periods of the same length; surprising flexibility in assembling and condensing; ease with which long period averages, totals and extremes can be worked out; work once done can be so arranged as to be done for all time; all the data for a year can be gotten on a form with sufficient particularity, without the form being of undue length, etc. I have found it convenient and profitable to make the last period one of ten days too, by running it into March four or five days. This simply doubles the use of the first days of March and does not, so far as I can see, affect any deductions harmfully. I have the average mean, maximum and minimum temperatures, average daily wind and average daily precipitation for each 10, 20, 30, 40, 60, 90, 120, 180, 240, 360, 480, 960 and 1920 days, under this system, ending at intervals of ten days

throughout the year, or thirty-seven times for each year, since the station was opened.

I would like to hear from others on this question. It is certainly worth looking into if it will, as I believe, save more than half the work in statistical meteorology. It is not nearly so wearisome to get original data as it is to handle the data afterward. The proposed system does away with more than half this drag work. The system of time division is, I believe, that adopted by the first French Republic. It is a great pity the reformers of that time could not force many of their reasonable and advantageous variations from the stupidities of mankind on the world and amongst others this beautiful division of days into decades.

ORIN PARKER.

COLUMBUS, OHIO, April 12, 1890.

CURRENT NOTES.

A VESSEL COLLIDES WITH A WATERSPOUT.—The following newspaper slip may be of sufficient importance in the study of waterspouts to be preserved for future reference because the waterspout appeared to have snow in the central part of the column:

"NEW YORK, March 15.—Sunday last the steamer *Slavonia* while 900 miles out at sea, collided with a waterspout, a towering column which united sea and sky. The waterspout hit the steamer's bow on the starboard side. A rushing noise accompanied the column, and the water foamed in its wake. Immediately above was a great black cloud from which clouds less dark descended to form an inverted cone. The middle of the column was white, apparently because it contained snow. The whole column had a spiral motion.

"The *Slavonia* shook under the shock, but kept on her course none the worse for the collision. A few flakes of snow on her prow were the only evidence of the collision. The vessel was uninjured, but the waterspout was wrecked and in fifteen minutes sank out of sight."

It would require but little rarefaction and cooling of the air

in winter on the ocean in the central part of the column to give rise to a freezing temperature, and so the vapor, passing in toward the center, would be frozen into snow, just as it is, where it ascends vertically, when it rises above the level of incipient freezing. W. F.

PROFESSOR RICHARD OWEN, the last of whose papers appears in the next number of the JOURNAL, died by accident on the 24th of last March at his home at New Harmony, Indiana. He came of a notable family, being the fourth son of Robert Owen, the Scotch philanthropist, who founded the colony at New Harmony. David Dale Owen, the geologist, and Robert Dale Owen were his brothers. He was born in Scotland in 1810, was educated in that country, in Switzerland, and, to some extent in this country to which he came as a young man. He was captain in the Mexican war and colonel in the civil war. Much of his life was spent as an educator and he was connected with several institutions as teacher, professor and president. His favorite science was geology but of late years he spent much thought and labor on magnetism. He was much respected and beloved by his fellow citizens. He was a brave soldier, an accomplished scholar, and a true Christian gentleman in the best sense of the word.

JAMES'S BAY.—The report of Mr. A. P. Low,—to the Canadian Geological Survey and published in its Annual Report for 1887–1888, appendix J,—of two seasons exploration about James's Bay, adds much to the geographical information about this little known region, but decidedly does not add to its attractiveness as a prospective place of residence. It seems that the south and west coasts are very low and swampy, and that the water shoals so gradually that, though the tide is only about five feet, open water is often not visible from the high water line. Indeed, the occupants of a canoe left midway by the tide are in an unhappy condition, for they must disembark in the mud, sometimes out of sight of the high water line and of open water, and patiently wait for the tide to return. The

mean summer temperature apparently falls below 55.5° F. or 19° C, which is not very unfavorable of itself, but when this is taken with a winter temperature which is, to the best of our knowledge, paralleled in Greenland, Nova Zembla and Siberia, the icy waters of the bay at all seasons, and other unpromising aspects of nature, the combination does not permit of as happy expectations as may be rationally entertained for higher latitudes farther west. Mr. Low seems to hold more favorable views, and suggests that James in 1631 exaggerated the story he told of excessive cold in the winter he spent there, when wine, vinegar, and even brandy were frozen solid, and a copper kettle, kept close to the fire, was warm on one side and had ice an inch thick on the other. However it may be as to James's story, the small size of the trees found and the arctic character of the flora, a list of which is given, indicate a climate which is colder than the latitude calls for, and a region not likely to prove hospitable to farmers. The rainfall appears moderate and the cloudiness not excessive.

EDITORIAL NOTE.

THE SUBSCRIPTION PRICE of the JOURNAL will, on and after this date, be $3.00. We are under the necessity of raising it to enable us to cover the expenses of publication. We hope that the increase in price will enable us to enlarge the JOURNAL, a step which the pressure of matter would justify. For this year, however, we will probably confine ourselves to the publication of an extra number containing the prize essays on tornadoes.

All contracts for subscription made previous to this date will, of course, continue as before until expiration.

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